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RELATIONS AMONG EQUIVALENCE, NAMING, AND CONFLICTING BASELINE CONTROL

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Three studies were conducted with different groups of 6 students each to explore the effects of training class-inconsistent relations and naming on demonstrations of emergent arbitrary stimulus relations. In all studies, two three-member equivalence classes of Greek symbols (A1B1C1 and A2B2C2) emerged as a result of training in conditional discriminations. Two new symbols were introduced (X and Y), and additional conditional discriminations were trained, whereby X was designated as the positive discriminative stimulus (S+) and Y was designated as the negative discriminative stimulus (S−) for A1 and B2. Conversely, Y was designated as the S+ and X as the S− for B1 and A2. This introduced conflicting sources of control within and between classes. In Study 1, subjects were not provided with names for the stimuli. In Study 2, the experimenter provided common names for the stimuli within each class. In Study 3, the subjects were required to use the common names during conditional discrimination training and test-trial blocks. In all experiments, equivalence responding with respect to the original classes was disrupted for some subjects subsequent to learning the new relations. Furthermore, in Studies 2 and 3, there were frequent examples of noncorrespondence between observed (listener or speaker) naming patterns and derived relations. These results support the view that demonstrations of equivalence are subject to control from a variety of sources rather than being fundamentally dependent on naming.

Key words: equivalence, naming, stimulus control, computer, humans

Studies of stimulus equivalence have made an important contribution to behavior analysis because they provide a framework for investigating emergent behavior that cannot be explained easily by reference to direct control by reinforcement contingencies. Such investigations have demonstrated that a number of complex arbitrary relations may emerge without specific training after subjects are presented with a series of conditional discriminations (e.g., Lazar, 1977; Sidman & Cresson, 1973; Sidman, Kirk, & Willson-Morris, 1985; Sidman & Tailby, 1982; Spradlin & Saunders, 1986).

An equivalence relation is defined fully by the demonstration of three emergent properties: reflexivity, symmetry, and transitivity (Sidman, 1990). *Reflexivity* is indicated when, if a stimulus (e.g., A1) is presented as a sample, A1 is also selected from a choice of comparisons (i.e., A1-A1). *Symmetry* is shown if it is demonstrated that each of the relations in original training is bidirectional, for example, by the demonstration of the B1-A1 relation following training of the A1-B1 relation. *Transitivity* is indicated if training of two of the relational pairs (e.g., A1-B1 and A1-C1) yields the demonstration of a third relation (i.e., B1-C1). A test for the emergence of an equivalence class consisting of A1, B1, and C1 can be conducted by examining whether the transitive relation is also bidirectional (i.e., B1-C1/C1-B1).

The literature on stimulus equivalence has highlighted a close link between equivalence and language. This has been apparent in studies of equivalence with language-able and language-disabled humans and with nonhuman species (e.g., D'Amato, Salmon, Loukas, & Tomie, 1985; Devaney, Hayes, & Nelson, 1986; Eikeseth & Smith, 1992; Lipkens, Kop, & Matthijs, 1988; Lowe & Beasty, 1987; Sidman et al., 1982). These studies appear to show that demonstrations of equivalence relations are dependent on the presence of an adequate verbal repertoire that facilitates the naming of stimuli, or at least on an ability to learn names for stimuli with specific training.

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As yet, however, no general agreement has been reached about the status of naming as a fundamental element, as a mediator, or as a derivative of equivalence.

Horne and Lowe (1996) offered a theoretical account of naming. They defined the naming relation as a fusion of speaker and listener functions that establishes a single, emergent bidirectional relation between speaking and listening. They held that the bidirectional property that is contained in the naming relation is fundamental to the emergence of equivalence relations. Thus, they proposed that ''Naming should not be viewed as *mediating* the establishment of stimulus classes: Naming *is* stimulus classifying behavior'' (pp. 226–227). They proposed several routes whereby naming of stimuli may be identified as fundamental to the emergence of equivalence relations: *A common name* may be applied to all potential class members. This may be an arbitrary label provided by the experimenter, a label attached to a perceived common feature of the potential class members by the subject, or a label for the nodal stimulus (i.e., ''the sample stimulus that during training was common to all of the stimulus pairings within a class,'' p. 221). Alternatively, *intraverbal naming* necessitates that each of the complete range of stimuli is named individually by the subject, so that bidirectional links can develop between the stimuli through self-echoic repetition of pairs of names related to each trained combination of stimuli.

Horne and Lowe's (1996) contribution has stimulated considerable discussion, particularly with reference to their claim that naming is the primary unit of behavior that occasions demonstrations of equivalence. Much of the empirical support for their view comes from observations and comparisons of equivalence performances with linguistic and nonlinguistic subjects (e.g., D'Amato et al., 1985; Lipkens et al., 1988; Sidman et al., 1982) or from manipulations and observations of naming in children with or without linguistic disabilities (e.g., Devaney et al., 1986; Eikeseth & Smith, 1992; Lowe & Beasty, 1987). Inevitably, such studies highlight the desirability of naming skills in the formation of equivalence relations. Nevertheless, the proposed status of naming as *fundamental* to equivalence performances has not yet been exposed empirically to the challenge of manipulation through other variables; for example, control from manipulation of baseline conditional discriminations. A demonstration of the primacy of naming under such conditions should indeed provide considerable support for a fundamental view of naming.

A variety of different emergent conditional discrimination patterns has been observed in studies using incongruous or reversed baseline discriminations to examine the integrity of original equivalence classes (e.g., Pilgrim, Chambers, & Galizio, 1995; Pilgrim & Galizio, 1990, 1995; Roche, Barnes, & Smeets, 1997; Saunders, Drake, & Spradlin, 1999; Saunders, Saunders, Kirby, & Spradlin, 1988). Both consistent and inconsistent conditional discrimination patterns emerged across these studies. Consistent patterns of response to particular trial types included maintenance of original symmetry and transitivity relations in a reversed baseline or reversed symmetry with maintained transitivity relations or reversed transitivity relations in keeping with the reversed baseline. Inconsistent patterns, in which responses varied from trial to trial of the same type, were observed particularly in children. These tended to reflect disruption to the original relations that was inconsistent with either the original or the reversed baseline (e.g., Pilgrim et al., 1995). Interpretations of differences in effects among these studies were offered in terms such as subtle procedural differences, demand characteristics, and the possible influence of verbal behavior.

Although various authors discussed verbal behavior as a possible mediating variable in these studies, such discussion was necessarily general and speculative, because naming manipulations were not a feature (e.g., Pilgrim & Galizio, 1995; Saunders et al., 1999). It is interesting, however, to consider what further possibilities might occur with the introduction of naming alongside baseline manipulations. The following computer-based studies with language-able students aimed to explore further the relative effects of control by ambiguous baseline relations and by naming on demonstrations of equivalence relations. In Study 1, ambiguous baseline control was introduced with established equivalence classes, A1B1C1 and A2B2C2, by presenting a pair of novel comparison stimuli, X and Y, for the training of new relations. When either A1 or B2 was presented as the sample, X was the positive discriminative stimulus (S+) comparison and Y was the negative discriminative stimulus (S−) comparison; when either B1 or A2 was the sample, Y was the S+ comparison and X was the S− comparison. This subjected one pair of stimuli from each equivalence class—that is, (A1 and B1) or (A2 and B2)—to conflicting sources of comparison stimulus control. In addition, it brought two pairs of stimuli from separate equivalence classes—that is, (A1 and B2) or (B1 and A2)—under a common source of comparison control. Thus, the nature of baseline control introduced through these new relations was ambiguous and presented a range of different possibilities for demonstrations of arbitrary stimulus relations.

In view of the range of emergent patterns observed in previous studies of baseline control and given the ambiguity of baseline relations in this study, it seems reasonable to suggest a range of possible outcomes in terms of a set theory view of equivalence (e.g., Sidman, 1994). Such possibilities could include a complete reorganization of the original A1B1C1 and A2B2C2 classes indicated by reversed symmetry and transitivity relations (i.e., A1B2XC2 and A2B1YC1) or a partial reorganization of the original classes indicated by reversed symmetry but maintained transitivity (i.e., A1B2XC1 and A2B1YC2). Alternatively, because the ambiguous relations with X and Y extend rather than negate the original baseline relations, maintenance of the original classes is also a possibility, as is an inconsistent pattern of arbitrary relations to reflect the ambiguity of baseline relations.

The introduction of common names for the stimuli in the original classes adds another dimension to these predictions, depending on the role that is assigned to naming in the formation of equivalence relations. If the original equivalence classes were driven fundamentally by a common name, for example, one might reasonably expect the classes to be preserved rather than disrupted, despite the ambiguous control from other sources if the naming pattern itself is unaffected by baseline contingencies. Alternatively, allowing for the possibility that naming itself may be subject to control from baseline contingencies, some disruption of naming could occur with conflicting control from baseline relations. This being the case, if naming is viewed as integral to the original equivalence classes, it seems reasonable to expect that disruption of naming patterns would be mirrored by disruption to the conditional discriminations that formed the original equivalence classes. In other words, one would expect to find a high degree of correspondence between maintained or disrupted symmetry, transitivity and naming patterns, if naming is taken to be fundamental to equivalence.

Study 1 was a preliminary study that explored the types of responses that could be expected without the provision of common names. Nevertheless, the importance of covert intraverbal naming in Horne and Lowe's (1996) theory was recognized and therefore the implications of individual subjects' spontaneous covert naming behavior were considered. In Studies 2 and 3, Study 1 was repeated with the added provision of common names for potentially equivalent stimuli by the experimenter (Study 2) or the use of common names for equivalent stimuli by the subjects (Study 3). These manipulations examined whether common naming, either at listener or speaker level, was effective in preserving the integrity of equivalence classes when conflicting baseline control was introduced. Thus, the outcomes of these latter studies are potentially valuable in evaluating whether naming indeed can be assigned a fundamental role in demonstrations of equivalence.

STUDY 1

Method

Subjects

Six students at the School of Psychology, Cardiff University, participated in the study in partial fulfillment of their course credit requirement for the school's internal subject panel and on the understanding that they would receive a 1-hr course credit plus the opportunity to earn up to £3 (approximately $4.80), which would be related to their performance during the experiment. It was specified that they should have no knowledge of Greek, even at the most basic level, and this was verified with each subject at the outset.

Apparatus

Six Greek letters were selected to form two potential three-member equivalence classes: Class A consisted of Φ (A1), Γ (B1), and Ω (C1). Class B consisted of Ξ (A2), δ (B2), and ξ (C2). Two additional Greek letters were selected to introduce the sources of conflicting comparison control later in the program: ϑ (X) and λ (Y). The stimuli were presented on an Apple Macintosh® computer, which also recorded data from keyboard responses. For each trial, the sample was presented on screen for 3 s. Then two comparisons (one stimulus from each potential class) appeared, one to the left and one to the right of the sample, which remained in view. The computer program required specification of a maximum time limit for stimulus presentation. This was set at 10 s, after which the screen went blank. The following trial was begun by a keyboard response at any time either during or after presentation of stimuli. Both of the response keys were marked with a blank sticker for location. The Z key (lower left of keyboard) was designated as the left response key, and the / key (lower right of keyboard) was designated as the right response key. Left and right presentations of potentially correct comparison stimuli were varied so that each of the comparison stimuli appeared with equal frequency in left and right positions.

Procedure

The following printed instructions were given to each subject at the beginning of the study:

> A sample stimulus will appear on screen for 3 seconds, then two additional stimuli will appear, one to either side of the sample. You need to learn which of these two stimuli to select, according to which sample is presented. If you think the stimulus to the left of the sample is correct, press the left marked key. If you think the stimulus to the right of the sample is correct, press the right marked key. I will say ''yes'' when you make a correct response or ''no'' when you make an incorrect response. Each time you make a correct response you will score 1 point. Each point is worth 1p [approximately 1.6 cents] and there are approximately 300 trials throughout the session, so potentially you can earn up to £3 in addition to your credit time. The computer will record all your responses throughout the session and you will be paid the sum of your points at the end. You have a maximum of 10 seconds within which to make your response.

The experimenter was seated behind and to the right of the subject. This arrangement enabled the experimenter to provide verbal feedback to the subject while remaining out of view. Any changes to the instructions were given verbally as the program progressed. Subjects completed a block of practice trials, which used Greek symbols different from the rest of the experiment (i.e., samples Π or ζ; comparisons ϕ and Ψ) but which otherwise exemplified the experimental procedure described below. When subjects met a criterion of 90% accuracy on practice trials, Phase 1 of the experiment began.

Phase 1

Conditional discriminations were trained and tested in the following sequence, which is summarized in Figure 1. Exposure to baseline conditional discrimination blocks was repeated until mastery criterion was attained at 10 of 10 correct responses in a block (or 9 of 10 if only the first response was incorrect).

Stage 1: Baseline training A1-B1 and A2-B2. Samples were either A1 or A2 with B1 and B2 as comparisons. Trials were mixed in blocks of 10 in a pseudorandom order (i.e., five of each matching-to-sample trial type). ''Yes'' or ''no'' feedback was given after each choice.

Stage 2: Symmetry test B1-A1 and B2-A2. For symmetry probe trials, samples were either B1 or B2 with A1 and A2 as comparisons. Trials were mixed in blocks of 20, consisting of 10 symmetry probe trials (five of each type) and 10 baseline trials, as in Stage 1. Subjects were informed that there would be no feedback during this stage.

Stage 3: Baseline training A1-C1 and A2-C2. Samples were A1 or A2 with C1 and C2 as comparisons. Blocks of 10 mixed trials (five of each type) were presented. ''Yes'' or ''no'' feedback was given after each choice.

Stage 4: Symmetry test C1-A1 and C2-A2. For symmetry probe trials, the sample was either C1 or C2 with A1 and A2 as comparisons. Trials were mixed in blocks of 20, consisting of 10 symmetry probe trials (five of each type) and 10 baseline trials, as in Stage 3. Subjects were informed that they would receive no feedback during this stage.

Phase 1			Phase 2		
Stage	Relation	No. trials per block	Stage	Relation	No. trials per block
1. Train	A1-B1 & A2-B2 (baseline)	5 + 10 total 5	7. Train	A1-X & A2-Y (conflicting)	5 + 10 total 5
2. Test	B1-A1 & B2-A2 (symmetry)	5 + 10 probes 5 + 10 baseline	8. Train	B1-Y & B2-X (conflicting)	5 + 10 total 5
3. Train	A1-C1 & A2-C2 (baseline)	5 + 10 total 5	9. Train mixed	A1-X/B1-Y & A2-Y/B2-X (conflicting)	10 + 20 total 10
4. Test	C1-A1 & C2-A2 (symmetry)	5 + 10 probes 5 + 10 baseline	10. Test	B1-A1 & B2-A2	5 + 10 probes 5 + 10 conflicting
5. Recap	Recap A1-B1 and A2-B2 training as Stage 1		11. Test	B1-C1/C1-B1 & B2-C2/C2-B2	10 + 20 probes 10 + 20 conflicting
6. Test	B1-C1/C1-B1 + B2-C2/C2-B2 (trans./equiv.)	10 + 20 probes 10 + 20 baseline	12. Retest	A1-B1/A2-B2 & A1-C1/A2-C2 (baseline recap)	10 + 20 total 10

Fig. 1. Sequence of training and test stages for Phases 1 and 2 in Study 1. "Yes" or "no" feedback was given on every trial in each training stage. No feedback was given for probe, baseline, or ambiguous trials in each test stage.

Stage 5. Recap A1-B1 and A2-B2 relations as in Stage 1.

Stage 6: Transitivity-equivalence test B1-C1, C1-B1, B2-C2, C2-B2. For transitivity-equivalence probe trials, either the samples were B1 or B2 with C1 and C2 as comparisons, or samples were C1 or C2 with B1 and B2 as comparisons. Blocks of 40 trials were presented, consisting of 20 probe trials (five of each type, above) and 20 baseline trials, as in Stages 1 and 3. Subjects were informed that there would be no feedback during this stage.

Phase 2

In this phase, two novel comparison stimuli, X and Y, were introduced. When either A1 or B2 was presented as the sample, X was the S+ comparison and Y was the S− comparison. When either A2 or B1 was presented as the sample, Y was the S+ comparison and X was the S− comparison. This subjected one pair of stimuli from each equivalence class—that is, (A1 and A2) or (B1 and B2)—to conflicting sources of comparison control. In addition, it brought the exemplars in two pairs of stimuli from opposite equivalence classes under a common source of comparison control—that is, (A1 and B2) or (A2 and B1). The sequence of training and testing during this phase was as follows:

Stage 7: Training A1-X and B1-Y. Samples were either A1 or B1 with X and Y as comparisons. Trials were mixed in blocks of 10 (five of each type). Feedback was given after each choice.

Stage 8: Training A2-Y and B2-X. Samples were either A2 or B2 with X and Y as comparisons. Trials were mixed in blocks of 10. Feedback was given after each choice.

Stage 9: Mixed training A1-X, B1-Y, A2-Y, B2-X. The trials described in Stages 7 and 8 were mixed in blocks of 20 trials (five of each type). Feedback was given after each choice.

Stage 10: Test B1-A1 and B2-A2 symmetry relations. This tested whether there was direct disruption to the previously established symmetrical A1-B1 and A2-B2 relations after differential S+ and S− comparison control was introduced for the stimuli within each pair. For probe trials, samples were either B1 or B2 with A1 and A2 as comparisons. 10 probes (five of each) were mixed with 10 ambiguous control trials (as in Stage 9), which presented as equal a representation as possible of the four ambiguous trial types. Subjects were informed that they would receive no feedback during this stage.

Stage 11: Test transitivity-equivalence relations B1-C1, C1-B1, B2-C2, C2-B2. This constituted a *combined* or *global* test (Sidman, 1994), to investigate whether there was indirect disruption of previously established equivalence relations after ambiguous comparison control was introduced within each class. For probe trials, either the samples were B1 or B2 with C1 and C2 as comparisons, or samples were C1 or C2 with B1 and B2 as comparisons. Blocks of 40 mixed trials were presented, consisting of 20 probe trials and 20 ambiguous control trials, as in Stage 9. Subjects were informed that there would be no feedback during this stage.

Stage 12: Retest for A1-B1, A1-C1, A2-B2, A2-C2 conditional discriminations. Two blocks of trials as described in Stages 1 and 3 (Phase 1) were given as a test without feedback to examine whether the original conditional discriminations that were trained at the start of Phase 1 remained intact at the end of the study.

Data recording. Data recording was automated via the computer program. On completion of the computer session, a questionnaire was presented, which probed for whether subjects had used any common or individual names for the stimuli during the experiment.

RESULTS

All subjects were proficient with responses (i.e., attaining 9 of 10 correct conditional discriminations) within a maximum of 2 blocks of practice trials. The criterion for mastery of the trained conditional discriminations for the experimental stimuli was 100% correct responses in a block of 10 trials, or 9 of 10 if only the first response was incorrect. All the subjects mastered the trained discriminations within a maximum of two training blocks for the relevant stage.

All subjects maintained 100% accuracy in the Phase 1 baseline conditional discrimination trials and in the new Phase 2 control discriminations with X and Y (A1-X, B1-Y, A2-Y, B2-X), which were embedded in the test blocks. All subjects demonstrated C1-A1 and C2-A2 symmetry at 100% accuracy in Phase 1. Figure 2 shows that all subjects demonstrated 100% accuracy with B1-A1 and B2-A2 symmetry trials and at least 90% accuracy for B1-C1/C1-B1 and B2-C2/C2-B2 transitivity trials in Phase 1. In Phase 2 a variety of patterns was observed. Subjects 1, 3, and 4 demonstrated minimal disruption to their original symmetry and transitivity relations, with the lowest score at 80% accuracy for symmetry with Subject 3. Subject 2 demonstrated reversal of original symmetry relations B1-A1 and B2-A2; the score of zero for these relations reflected consistent B1-A2 and B2-A1 scores in Phase 2. In contrast, transitivity relations B1-C1/C1-B1 B1-C2/C2-B2 remained intact in Phase 2 for Subject 2. Subjects 5 and 6 demonstrated reversal of original symmetry and transitivity relations in Phase 2, with scores of zero in each case.

Phase 2 retest for A1-B1, A1-C1, A2-B2, A2-C2 conditional discriminations (Stage 12). All subjects except Subject 5 demonstrated that these original conditional discriminations were maintained at 100% accuracy. Subject 5 scored zero in both trial blocks. Therefore the original conditional discriminations were reversed completely for this subject (i.e., A1-B2, A1-C2, A2-B1, A2-C1).

Stimulus naming. Each subject's reported naming of individual stimuli in the postexperimental questionnaires is shown in Table 1. None of the subjects reported using common names for the stimuli. However they all reported having individual names for some of

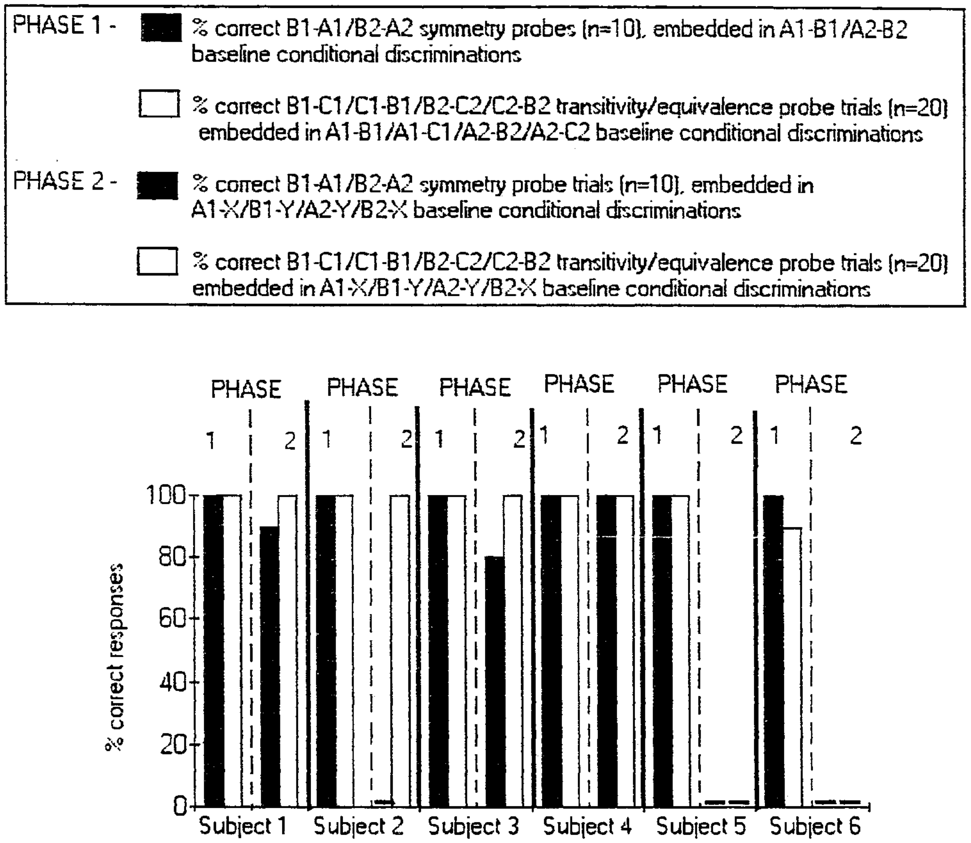

Fig. 2. Performance on symmetry and transitivity-equivalence probe trials in Phase 1 and Phase 2 tests in Study 1.

the stimuli. Subjects 2 and 5 reported naming patterns that conform to the conditions proposed by Horne and Lowe (1996), whereby naming of individual stimuli may underlie the demonstration of equivalence; Subject 2 named the nodal stimuli (A1 and B1), and Subject 5 named all the stimuli within each set. The naming patterns for the other subjects did not appear to conform to these conditions insofar as they did not report naming the nodal stimuli or all the stimuli individually.

Discussion

To summarize performances in Phase 2, Subjects 1, 3, and 4 maintained all their original relations from Phase 1. For Subject 2, the former symmetry relations were reversed to produce new relations B1-A2 and B2-A1, but the transitivity-equivalence relations re-

Table 1

Study 1. Reported naming of individual stimuli. Symbols indicate whether the subject did (+) or did not (−) report having a name for the stimulus during the experiment.

Subject	A1	B1	C1	A2	B2	C2	X	Y
1	−	+	+	−	+	−	+	+
2	+	−	−	+	−	−	−	−
3	+	+	+	−	−	−	−	−
4	−	+	−	−	+	−	+	+
5	+	+	+	+	+	+	+	+
6	−	+	+	−	+	+	−	−

mained intact. With Subject 5, the previously demonstrated symmetry and transitivity-equivalence relations and the original trained relations were reversed. For Subject 6, symmetry and transitivity-equivalence relations were reversed, and the original trained relations remained intact.

It was noted previously that the performances of only 2 subjects (Subjects 2 and 5) conformed to the conditions proposed by Horne and Lowe (1996) for naming to account for their original demonstrations of equivalence in Phase 1. These naming patterns may also be used to interpret their Phase 2 performances.

According to Horne and Lowe's (1996) analysis, the naming of nodal stimuli (A1 and B1) by Subject 2 could have produced the original demonstration of equivalence in Phase 1 by providing a common name for each trained stimulus pairing. In Phase 2, the X and Y stimuli introduced new stimulus pairings that did not share the original nodal name, so this could have changed the pattern of relations. For example, the original relations B1-A1 and B2-A2 could have been redefined thus: A2-Y, B1-Y, therefore B1-Y-A2 (and likewise, B2-X-A1). This, then, could have produced the changed relations in Phase 2 symmetry tests. Therefore, although there may be alternative explanations for this performance, both the original demonstrations of equivalence and subsequent disruption of symmetry can be accommodated within Horne and Lowe's analysis. The transitivity-equivalence relations and the original baseline relations remained intact in Phase 2 (Stages 11 and 12), so these new relations did not seem to constitute equivalence classes but suggested a series of flexible relations. To illustrate, Phase 2 relations were A1-B1 and A2-B2 in the Stage 12 baseline check but were B1-A2 and B2-A1 when they were set into the ambiguous baseline for the Stage 10 symmetry test. By contrast, the B1-C1/C1-B1 and the B2-C2/C2-B2 relations remained intact in the Phase 11 transitivity-equivalence test *independently* of their setting as probe trials in the ambiguous baseline relations. Assuming that nodal naming was a constituent of these performances in Phase 2 and considering that there was no direct differential training of X and Y stimuli with the C stimuli, it is possible that the maintained transitivity relations reflected adherence to the original named nodal relations with the A stimuli. This analysis does not, of course, specify the only logical choice open to Subject 2, given the range of possibilities raised by the conflicting baseline relations. Rather, it acknowledges that this particular performance can be explained in terms of naming and presents no major difficulty for naming theory.

Subject 5 apparently fulfilled the criteria for the demonstration of equivalence through intraverbal naming by having individual names for all the stimuli. Therefore this can be interpreted in terms of Horne and Lowe's (1996) analysis. In Phase 2 there was disruption in tests for symmetry and transitivity-equivalence relations, and entirely new, reversed relations were demonstrated (i.e., new relations were B1-A2 and B2-A1 in symmetry tests and B1-C2/C2-B1 and B2-C1/C1-B2 in transitivity-equivalence tests). Naming of X and Y stimuli was also reported by this subject. Therefore it is possible that as for Subject 2, the new relations that were observed in Phase 2 reflected new intraverbal links, which could have been established through the X and Y stimuli. The original baseline relations were also reversed in Stage 12, so it seems that the equivalence classes were reversed entirely for Subject 5; this could be explained in terms of intraverbal naming.

Performances based on the naming reports by Subjects 1, 3, 4, and 6 are somewhat more difficult to interpret in terms of Horne and Lowe's (1996) analysis because they each reported naming only some of the stimuli. None of the reported naming patterns fulfills the conditions specifically proposed by Horne and Lowe (1996), for naming to account for the maintained emergent relations of Subjects 1, 3, and 4 or for the reversed emergent relations demonstrated by Subject 6 in Phase 2. However, it cannot be established from this whether the subjects were using names privately during the experiment, which were not reported in the questionnaires. This has been recognized previously as an inherent weakness of postexperimental naming questionnaires (e.g., Horne & Lowe, 1996; Stoddard & McIlvane, 1986). Therefore an analysis of naming behavior in this study might perhaps have been served better by adopting a ''think aloud'' procedure, requiring the subjects to comment on the reasons for their selections concurrently with their conditional discriminations. An alternative strategy, which would permit a more direct evaluation of the effects of naming and ambiguous comparison control, would be to teach standard names concurrently with conditional discrimination training. Studies 2 and 3 adopted this procedure under conditions in which the subjects were not required to speak the names aloud (Study 2) and in which they were required to speak names aloud (Study 3).

There was considerable variation among the subjects' performances in Study 1, which could be taken to reflect the ambiguous nature of control from baseline relations. This ambiguity was intentional, insofar as the novel stimuli introduced a variety of different possible emergent relations alongside the original relations, none of which technically were either correct or incorrect. In this case, the variation in response patterns does not seem to be unreasonable, because the subjects were deprived of a clear basis for selection due to the competing baselines (i.e., the original vs. the ambiguous relations). In this case, it would be neither more nor less reasonable to respond on the basis of the original baseline relations, preserving the relations demonstrated by Subjects 1, 3, and 4; or on the basis of the new baseline, producing completely reversed classes demonstrated by Subject 5; or on the basis of both the original and the new relations, producing the dissociations observed between preserved baseline and reversed symmetry relations with Subject 2 and between preserved baseline and reversed symmetry-transitivity relations with Subject 6. As discussed earlier, each of these response patterns has been observed in previous studies (e.g., Pilgrim et al., 1995; Pilgrim & Galizio, 1990, 1995; Roche et al., 1997; Saunders et al., 1992, 1999).

To summarize, the main findings from Study 1 suggest that although stimulus naming can provide a satisfactory account of some of these subjects' performances, it cannot be established from the data whether individual naming of stimuli served a primary or fundamental role in each case. As stated previously, although the possibility of covert naming was considered, the primary aim of this study was to explore whether equivalence relations could be disrupted when names were not provided specifically. This should serve as a point of comparison with performances when names are provided.

In Study 2, the procedures of Study 1 were repeated with different subjects, and common names were provided for potentially equivalent stimuli concurrently with conditional discrimination training. This permitted a more direct examination of the relative effects of naming and conflicting baseline control on demonstrations of emergent relations, because the availability of names and manipulations of comparison control were standard for all subjects.

STUDY 2

Method

Subjects

Six students were recruited from the School of Psychology internal subject panel according to the criteria described in Study 1.

Apparatus

The same stimuli as those used in Study 1 were presented on an Apple Macintosh computer. The computer-generated training and testing sequences were the same as for Study 1 (Figure 1) with the addition of four presentations of a block of 18 additional trials to test for stimulus-label correspondences. This block was presented twice after the Phase 1 Stage 6 transitivity-equivalence test and twice after the Phase 2 Stage 11 transitivity-equivalence test. On these trials, two stimuli (one each from Set 1 and Set 2) were presented adjacent to each other for a possible 10 s. A keyboard response before this time terminated the trial and the following trial was presented. Eighteen trials were prepared to allow one presentation of each possible pairing of stimuli from Set 1 and Set 2 in left and right positions in a pseudorandom order. These additional trial blocks and the provision of common names were integrated into the program as described below.

Phase 1

Stage 1: Naming with A1-B1 and A2-B2 training. The experimenter said "alpha" when the A1 stimulus appeared as the sample or "beta" when the A2 stimulus appeared as the sample.

Stage 2: Naming with B1-A1 and B2-A2 sym-

metry test. The names were provided for samples both on baseline and on probe trials, that is, the experimenter said ''alpha'' when either A1 or B1 was the sample and ''beta'' when A2 or B2 was the sample.

Stage 3: Naming with A1-C1 and A2-C2 training. The experimenter said ''alpha'' when A1 was the sample or ''beta'' when A2 was the sample.

Stage 4: No naming with C1-A1 and C2-A2 symmetry test. No names were provided for sample stimuli during this section to allow a later naming test for C1 and C2 stimuli. This would verify whether names were emergent for these stimuli through the training in conditional discriminations and thus whether names and equivalence relations were integrated fully at the end of Phase 1. Therefore, this symmetry test was conducted as for Phase 1 in Study 1.

Stage 5. No names for A1-B1 and A2-B2 recap trials.

Stage 6: No names with B1-C1/C1-B1 and B2-C2/C2-B2 transitivity-equivalence tests. This test was conducted as described for Phase 1 in Study 1.

Additional Stage A: Testing selection of Set 1 stimuli to alpha. Subjects were informed that the following trials were taking a different form from the previous stages, that is, only two stimuli would appear on screen on each trial. They were instructed to identify alpha stimuli by pressing the left response key if they thought it was on the left of the display or the right response key if they thought it was on the right. No feedback was provided throughout this stage. The format for stimulus pairings is described above.

Additional Stage B: Testing selection of Set 2 stimuli to beta. The test block was presented again, and subjects were instructed to identify beta stimuli in the same way as they had previously identified alpha stimuli.

Phase 2

Phase 2 was as described for Phase 2 in Study 1, that is, no names were provided by the experimenter throughout the training and test stages. Two additional blocks of test trials for selection of alpha and beta stimuli were presented between the transitivity-equivalence test and the test for maintenance of the original trained relations (i.e., between Stages 11 and 12 in Study 1, Phase 2).

Results

All subjects mastered the practice trials within two blocks. The criterion for mastery of the trained conditional discriminations for the experimental stimuli (i.e., 100% correct responses in a block of 10 trials, or 9 of 10 correct responses if only the first response was incorrect) was attained by all subjects within two training blocks for the relevant stage.

Scores for the pretrained conditional discriminations embedded in the Phase 1 (Stages 2 and 6) and Phase 2 (Stages 10 and 11) tests for symmetry and transitivity were maintained at 100% for all subjects (Figure 3). All subjects demonstrated B1-A1, C1-A1, B2-A2, and C2-A2 symmetry with 100% accuracy in Phase 1. In the Phase 1 Stage 6 test for B1-C1/C1-B1 and B2-C2/C2-B2 transitivity relations, Subjects 1 through 4 scored 100%, Subject 5 scored 75%, and Subject 6 scored 90%. In Phase 2, all subjects' conditional discrimination patterns fell into either of two categories. For Subjects 1, 2, and 5, the original symmetry and transitivity patterns were reversed in Phase 2 (Stages 10 and 11), reflected by their zero or near-zero scores on both tests. For Subjects 3, 4, and 6, there was a dissociation between reversed symmetry patterns indicated by scores of zero in the Stage 10 symmetry test and maintained transitivity relations indicated by scores of 100%.

Stimulus selection to name test. All subjects scored 100% in the test for selection of alpha stimuli and in the test for the selection of beta stimuli in both Phase 1 and Phase 2.

Phase 2 recap test for A1-B1/A1-C1 and A2-B2/A2-C2 (original baseline) relations. Scores of 100% for all subjects in two test blocks of 10 trials confirmed that they maintained their original trained relations after the introduction of conflicting control. The overall pattern of performance in Phase 2 is illustrated for each subject in Table 2.

Discussion

All subjects demonstrated symmetry at 100% correct in Phase 1 and, with the exception of Subject 5, they all attained the criterion set for the mastery of the baseline relations (90% or above) for the Phase 1 transitivity-equivalence baseline relations. The 75% accuracy rate for Subject 5 in the

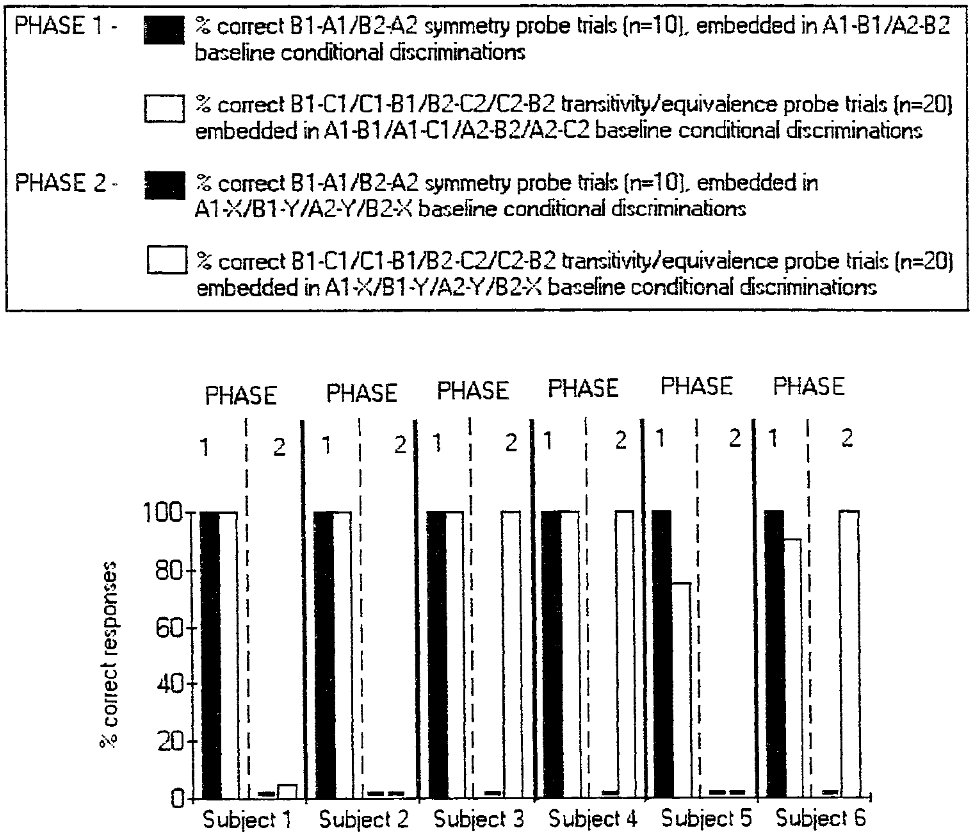

Fig. 3. Performance on symmetry and transitivity-equivalence probe trials in Phase 1 and Phase 2 tests in Study 2.

transitivity-equivalence test indicated that this performance was less consistent than for the other subjects. Therefore, Phase 2 results for Subject 5 should be interpreted in light of this. Scores for selection of alpha or beta stimuli were correct consistently for all subjects. Because names were never provided directly when either C1 or C2 was the sample, this indicates that the names for these stimuli emerged through the other relations, and therefore common names and equivalence classes were shown to be integrated with each other by the end of Phase 1. A possible exception is the naming and transitivity-equivalence patterns demonstrated by Subject 5, whose 100% score for the naming test compared with a less consistent 75% score for the transitivity-equivalence test.

In Phase 2, all subjects demonstrated disruption of their former B1-A1 and B2-A2 relations after conflicting S+ and S− relations were introduced. Instead they demonstrated new emergent relations B1-A2 and B2-A1. In contrast, the common naming patterns, which previously were integrated with equivalence classes, were maintained at the end of Phase 2. This suggests a dissociation in Phase 2 between formerly integrated conditional discriminations and naming patterns and that the new emergent relations demonstrated in the Phase 2 symmetry test were caused by the introduction of the new relations trained with the X and Y stimuli, which overrode the common names. However, it should be considered that the naming tests were given in isolation and not within a baseline of the new relations with X and Y. Had this been the case, it is possible that the naming patterns could have reflected these new relations. This question is addressed in Study 3, in which overt naming tests were given in test blocks that included the X and Y relations.

The performances in the Phase 2 transitivity-equivalence tests were more variable across

Table 2

Patterns of disruption in Phase 2 to relations demonstrated in Phase 1 of Study 2. A + indicates that previously demonstrated relations were disrupted in Phase 2. A − indicates that previously demonstrated relations remained intact in Phase 2.

Subject	Symmetry B1-A1/B2-A2	Transitivity-equivalence B1-C1/C1-B1 B2-C2/C2-B2	Original A1-B1/A1-C1 A2-B2/A2-C2	Select alpha or beta
1	+	+	−	−
2	+	+	−	−
3	+	−	−	−
4	+	−	−	−
5	+	+	−	−
6	+	−	−	−

the group of subjects. Three subjects (Subjects 3, 4, and 6) maintained the original relations in Phase 2; Subjects 1 and 2 demonstrated complete reversal of their Phase 1 relations, and Subject 3 demonstrated a shift from significant transitivity-equivalence relations in Phase 1 to entirely new relations B1-C2/C2-B1 and B2-C1/C1-B2.

These findings with reference to common naming appear to challenge Horne and Lowe's (1996) view that naming is fundamental (i.e., both necessary and sufficient) for the demonstration of equivalence relations because of the bidirectional element that they propose is contained within the naming relation. According to this reasoning, if the participants were using the common names as a basis for their conditional discriminations, this should have been more likely to maintain the original bidirectional relations in Phase 2. On the contrary, in the current study, the relations that could have been defined by the common names were overridden by the conflicting sources of control in Phase 2.

However, there is another consideration to take into account before this can be established. Although the common names were provided and the subjects integrated these with equivalence classes originally, it cannot be assumed that they continued using the names in Phase 2, even though the Phase 2 naming test confirmed that these naming patterns were maintained. It is possible, for example, that some subjects used an alternative strategy by adopting new individual names for the X and Y stimuli and arriving at the new relations via this route, as discussed previously for some subjects in Study 1. Subjects' naming of individual stimuli was not assessed in this study because common names were supplied as standard; therefore, naming tests focused on the common naming patterns. This allows the possibility that if common names are provided in a listener capacity only, patterns of emergent conditional discriminations may reflect the use of alternative private naming strategies that do not correspond with the common names. This problem is addressed in Study 3, in which 6 additional subjects were trained during the course of the procedure to speak aloud common names for potentially equivalent stimuli when they were presented as samples. This was intended to clarify whether dissociation between common naming and equivalence relations can occur when the common names are observed to be applied to potentially equivalent stimuli. Outcomes should provide a more direct evaluation of the role of naming in this instance because it seems considerably less likely that subjects would use an alternative covert naming strategy concurrently with overt naming patterns.

STUDY 3

Method

Subjects

Six students were recruited from the internal subject panel at the School of Psychology, under the same conditions as for Studies 1 and 2.

Apparatus

The same stimuli as those used in Study 1 were presented on an Apple Macintosh computer. The computer-generated training and testing sequences were the same as for Study 1 (Figure 1), with training and testing for the use of common names integrated into the program as described below.

Phase 1

The experimenter said "alpha" for Set 1 stimuli or "beta" for Set 2 stimuli when these were presented as samples during Stages 1 through 3.

Stage 1. Baseline A1-B1 and A2-B2 relations.

Stage 2. Symmetry test for B1-A1 and B2-A2 relations.

Stage 3. Baseline A1-C1 and A2-C2 relations.

Stage 4. No names were supplied in tests for C1-A1 and C2-A2 symmetry.

Stage 5. No names were supplied in recap trials for A1-B1 and A2-B2 baseline relations.

Stage 6: Naming during B1-C1/C1-B1 and B2-C2 /C2-B2 transitivity-equivalence test. The subjects were requested to say aloud "alpha" or "beta" when a sample stimulus appeared on screen, according to which of these names they thought was applicable. The experimenter (seated to the right just behind the subject) scored their responses on a preprepared sheet. A naming response was scored as correct only if the subject produced a single appropriate name. All other responses (i.e., multiple, inappropriate, or absent) were marked as incorrect. No feedback was given for correct, incorrect, or ambiguous naming responses. However, if a subject failed to produce a name on a particular trial, he or she was reminded to produce a name on future trials.

Phase 2

The schedule for training and testing of conditional discriminations was the same as for Phase 2 in Studies 1 and 2. Sample-stimulus naming was integrated into this program as follows:

Stages 7 through 9: Baseline A1-X, B1-Y, A2-Y, and B2-X relations. Subjects were not required to name sample stimuli aloud during training of these new relations.

Stage 10: Symmetry test for B1-A1 and B2-A2 relations. Subjects were required to name the sample stimuli aloud, as described for Stage 6 in Phase 1.

Stage 11: Transitivity-equivalence test for B1-C1/C1-B1 and B2-C2/C2-B2 relations. Subjects were required to name sample stimuli aloud.

Stage 12: Recap test for original A1-A2, A1-A3, B1-B2, and B1-B3 relations. Subjects were not required to name sample stimuli aloud during this phase.

RESULTS

All subjects mastered the practice trials within two blocks and mastered the trained conditional discriminations with the experimental stimuli within two training blocks at the relevant stage (i.e., they attained 100% correct responses in a block of 10 trials or 9 of 10 if only the first response was incorrect).

Scores for the pretrained conditional discriminations embedded in Phase 1 (Stages 2 and 6) and Phase 2 (Stages 10 and 11) tests for symmetry and transitivity-equivalence were maintained at 100% for all subjects (Figure 4). All subjects demonstrated 100% accuracy in the Phase 1 tests for B1-A1, C1-A1, B2-A2, and C2-A2 symmetry relations. In the Phase 1 (Stage 6) test for B1-C1/C1-B1 and B2-C2/C2-B2 transitivity-equivalence relations, all subjects, with the exception of Subject 2, scored at or above the 90% criterion set for the trained conditional discriminations. The score for Subject 2 was less consistent but at 85% was close to the 90% criterion.

Performances were more variable in Phase 2 (Figure 4). Subjects 4 and 5 maintained their original symmetry and transitivity-equivalence relations at 100%. The pattern for Subject 2 suggested less consistent but nevertheless general maintenance of the original relations: Responses reflecting the original symmetry relations decreased slightly to 80%, and responses reflecting the original transitivity-equivalence relations increased to 100% (from 85%) in Phase 2. Subject 3 demonstrated reversal of the original symmetry relations, with a score of zero in Phase 2, but general maintenance of the transitivity-equivalence relations, which decreased only slightly to 80%. For Subject 1, the score for responses reflecting the original symmetry relations decreased to 40% (from 100%), indicating that these relations were disrupted, while the original transitivity relations were maintained at criterion. Subject 6 demonstrated reversal of the original symmetry relations with a score

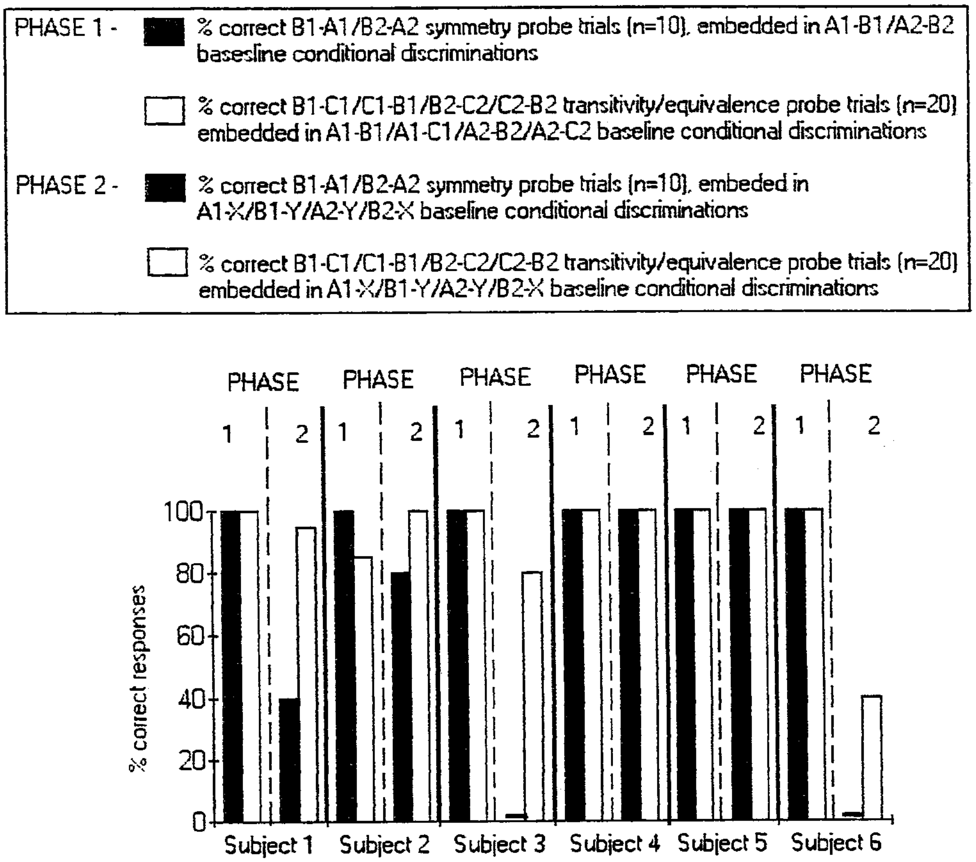

Fig. 4. Performance on symmetry and transitivity-equivalence probe trials in Phase 1 and Phase 2 tests in Study 3.

of zero and disrupted transitivity-equivalence relations at 40% (from 100%).

Correspondences between conditional discriminations and sample naming in Phase 2 tests for B1-A1 and B2-A2 relations. The scores for sample naming with emergent conditional discrimination trials are presented in Figure 5, and scores for sample naming with ambiguous relations A1-X, B1-Y, A2-Y, and B2-X are presented in Figure 6. Figure 5 shows that Subjects 4 and 5 retained their original B1-A1 and B2-A2 relations fully and correspondingly demonstrated consistently accurate naming of samples. For Subject 2, B1-A1 and B2-A2 relations were generally accurate at 8 of 10 correct in Phase 2, and responses for stimulus naming were 100% accurate. Subject 1 demonstrated substantial disruption in the emergent relations (from 10 of 10 correct in Phase 1 to 4 of 10 correct in Phase 2) but sample naming generally was consistent, with 8 of 10 accurate responses. Similarly, Subject 3 demonstrated reversed emergent relations (B1-A2 and B2-A1) but sample naming was generally consistent with 8 of 10 accurate responses. Subject 6 demonstrated reversed emergent relations, and sample naming was inconsistent with 4 of 10 accurate responses.

Figure 6 shows that sample naming with ambiguous baseline trials A1-X, B1-Y, A2-Y, and B1-X maintained a consistently accurate level for Subjects 1, 2, 3, 4, and 5. For Subject 6, sample naming was less accurate, with 6 of 10 correct responses for ambiguous baseline trials.

Correspondences between conditional discriminations and sample naming in Phase 1 and Phase 2 tests for B1-C1/C1-B1 and B2-C2/C2-B2 (transitivity-equivalence) relations. The scores for sample naming with emergent conditional discrimination trials are presented in Figure 7, and scores for sample naming with ambig-

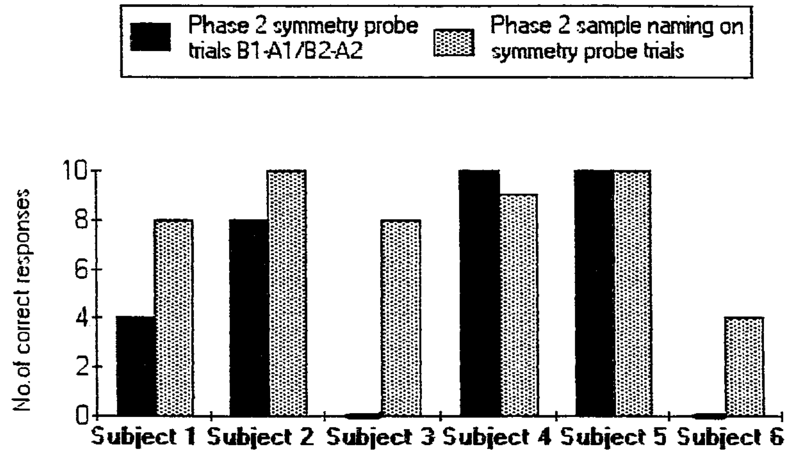

Fig. 5. Correspondence between responses on symmetry probe trials and sample naming during Phase 2 tests for B1-A1 and B2-A2 relations in Study 3.

uous relations A1-X, B1-Y, A2-Y, and B2-X are presented in Figure 8. Figure 7 shows that Subject 1 demonstrated equivalence relations in Phase 1, but sample naming was inconsistent at 11 of 20 correct responses; in Phase 2, equivalence relations (17 of 20) and sample naming (18 of 20) were generally accurate. Subject 2 demonstrated a high level of consistency with equivalence relations (17 of 20) and sample naming (17 of 20) in Phase 1 and full correspondence between equivalence relations and sample naming in Phase 2. Subject 3 demonstrated full consistency between equivalence relations and sample naming in Phase 1; in Phase 2 the equivalence score decreased slightly to 16 of 20 and the naming score decreased substantially to 10 of 20. For Subjects 4 and 5, there was full correspondence between sample naming and equivalence relations in Phases 1 and 2. Subject 6 demonstrated almost full correspondence between scores for equivalence probes (20 of 20) and sample naming (19 of 20); in Phase 2, scores decreased substantially to 8 of 20 for equivalence probes and 11 of 20 for sample naming.

Figure 8 shows that in Phase 1, Subject 1 was 100% accurate in baseline relations, but sample naming was inconsistent with 14 of 20 correct responses, a nonsignificant level of ac-

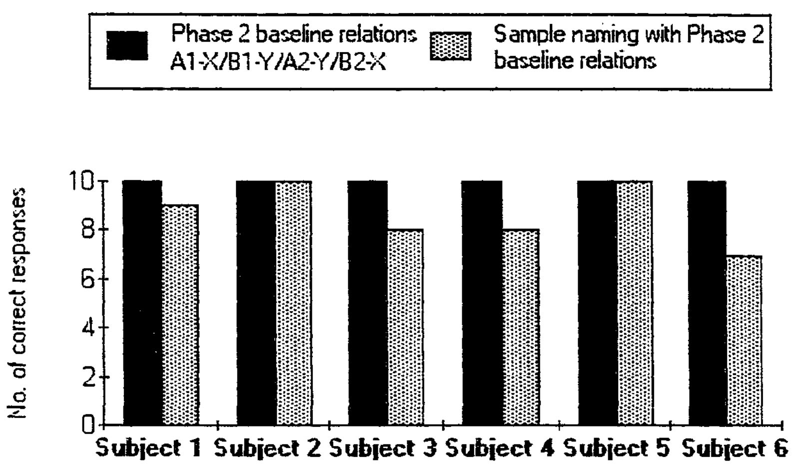

Fig. 6. Correspondence between responses for ambiguous baseline relations A1-X, B1-Y, A2-Y, and B2-X and sample naming during Phase 2 tests for B1-A1 and B2-A2 relations in Study 3.

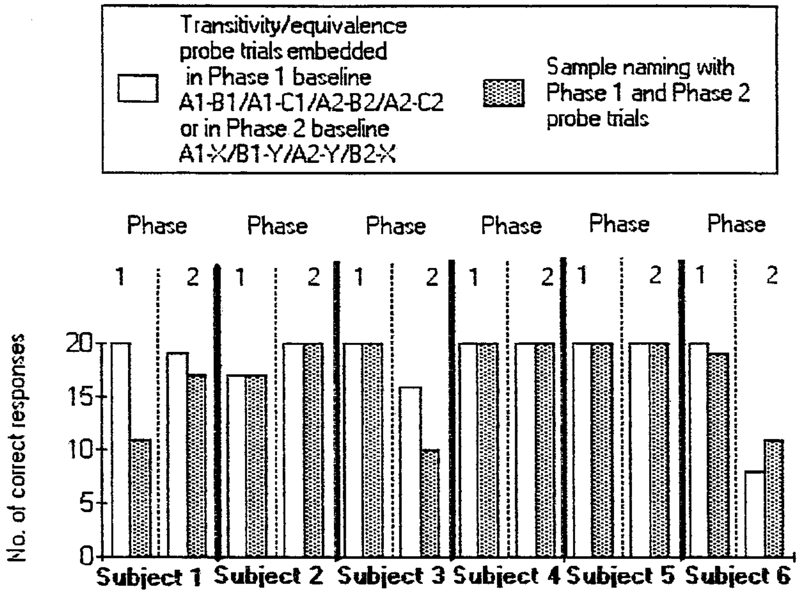

Fig. 7. Correspondence between responses on transitivity-equivalence probe trials and sample naming during Phase 1 and Phase 2 tests for B1-C1/C1-B1 and B2-C2/C2-B2 relations in Study 3.

curacy with a binomial test. In Phase 2, the accuracy of ambiguous relations was 100% and the accuracy of sample naming increased to 18 of 20. Subjects 2, 4, and 5 demonstrated high or full correspondence between baseline relations and sample naming in Phase 1; in Phase 2, their ambiguous relations were fully accurate and their sample naming was maintained at 100% accuracy. Subject 3 demonstrated full correspondence between baseline relations and sample naming in Phase 1; in Phase 2, ambiguous relations were fully ac-

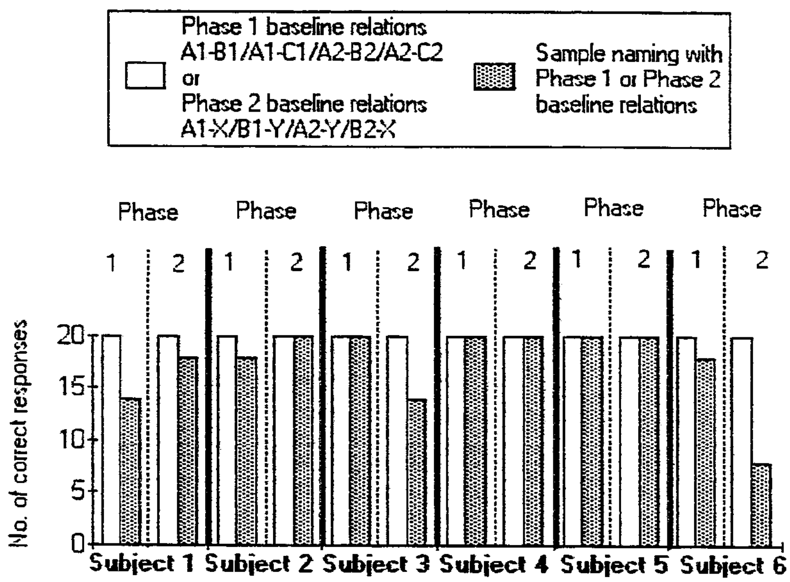

Fig. 8. Correspondence between responses on A1-B1, A1-C1, A2-B2, and A2-C2 baseline trials and sample naming in Phase 1 and between A1-X, B1-Y, A2-Y, and B2-X ambiguous baseline relations and sample naming in Phase 2 tests for B1-C1/C1-B1 and B2-C2/C2-B2 relations in Study 3.

curate but sample naming was inconsistent at 14 of 20 correct. Subject 6 demonstrated high correspondence between scores for baseline relations (20 of 20) and sample naming (18 of 20) in Phase 1; in Phase 2, ambiguous relations were 100% accurate but sample naming decreased to 8 of 20 correct.

Recap test for baseline relations: A1-A2, A1-A3, B1-B2, and B1-B3. Subjects 1, 2, 3, 4, and 5 scored 100% for both trial blocks in the final tests that assessed whether the original trained relations had been maintained after Phase 2 manipulations. Subject 6 scored 50% for each block of trials, indicating that his original baseline relations were disrupted in Phase 2.

Discussion

The requirement for overt common naming in this study provided the opportunity to explore the patterns of correspondence between emergent relations and naming within either defined or conflicting baselines. Such data are of particular interest because they allow a more direct evaluation of the role of naming in equivalence than Studies 1 and 2.

Three subjects (Subjects 2, 4, and 5) demonstrated high or full maintenance of symmetry and transitivity-equivalence relations and corresponding sample naming throughout Phases 1 and 2, despite the ambiguity of the baseline relations in Phase 2. These results are consistent with an account of equivalence in terms of common naming as proposed by Horne and Lowe (1996). This pattern could be interpreted as consistent common naming taking primacy and preserving equivalence relations that were set in an otherwise ambiguous baseline. Subjects 1, 3, and 6, however, demonstrated various patterns of disruption and noncorrespondence between naming and emergent relations. These patterns seem to present a challenge to Horne and Lowe's view of naming as fundamental, in the sense that naming is both necessary and sufficient to produce demonstrations of equivalence relations.

Horne and Lowe (1996) proposed that a common name is a special case of common responding because of the bidirectional element contained within the name–referent relation through the echoic (i.e., overt or covert production of the name). This is proposed to effect a common bidirectional link (and therefore equivalence) between all stimuli bearing the same name.

Two deductions arising from Horne and Lowe's (1996) analysis seem to be reasonable. In the first instance, if the relation between the stimuli is *necessarily* defined by the common name, then stimuli that are shown to relate to each other through the properties of equivalence should also be shown to bear a common name. In the current study, this was not the case for Subject 1, who in the Phase 1 transitivity-equivalence test demonstrated equivalence relations with 100% accuracy but inconsistent naming of equivalent stimuli at 55% accuracy. There was a similar, although perhaps less decisive, pattern for Subject 3, who maintained a high level of consistency with equivalence relations at 80% but showed substantially disrupted naming to 50% in the Phase 2 transitivity-equivalence test. In both cases, it seems that consistent common naming was not necessary for the demonstrations of equivalence.

In the second instance, if the relation between the stimuli is *sufficiently* defined by the common name, it seems reasonable to assume that in cases in which stimuli are shown to bear a common name, the properties of equivalence between them should also be in evidence. However, this did not occur with Subject 1 or Subject 3 in the Phase 2 test for B1-A1 and B2-A2 relations. Instead, although sample naming was generally consistent (8 of 10 correct responses for both subjects), the B1-A1 and B2-A2 relations were disrupted substantially to 4 of 10 for Subject 1 and were reversed completely, with a score of zero, for Subject 3. Therefore consistent naming did not appear to be sufficient to maintain demonstrations of symmetry by Subjects 1 and 3 in Phase 2. Given the patterns of noncorrespondence between naming and equivalence relations that occurred throughout testing for Subjects 1 and 3, these data seem to challenge Horne and Lowe's (1996) view of the fundamental (i.e., sufficient and necessary) role of naming in equivalence relations.

The Phase 2 performance of Subject 6 is difficult to interpret distinctly in terms of control from either ambiguous baseline relations or naming. The original symmetry relations were reversed completely in Phase 2, and inconsistent sample naming and disruption of original baseline relations accompanied this. Clearly then, these new reversed relations were not driven by the variable naming patterns or by the original baseline conditional discriminations. Therefore, it is reasonable to conclude that these new relations developed through the new trained relations with X and Y stimuli, which disrupted not only previous equivalence relations but also previous common naming patterns. This seems to challenge the primacy of naming in equivalence relations. However, it cannot be determined from the current data whether Subject 6 was applying different names privately to the X and Y stimuli because they appeared only as comparisons rather than as named samples. Had he been doing so, then as discussed previously for individual subjects in Studies 1 and 2, the new relations conceivably could have developed through these names.

To summarize, the data from Subjects 1 and 3 challenge an interpretation of naming as fundamental to demonstrations of equivalence because of the patterns of noncorrespondence observed between consistent common naming and disrupted equivalence relations or vice versa. The data from Subject 6 are less compelling but nevertheless suggest the possibility that ambiguous baseline relations can disrupt previously established equivalence relations and concurrent common naming patterns.

GENERAL DISCUSSION

This series of studies aimed to explore the relative effects of control by conflicting baseline relations and naming on demonstrations of stimulus equivalence. There was considerable variability among the subjects' performances within each study.

In Study 1, in which no names were provided, previously established symmetry or transitivity relations were disrupted for 3 subjects but remained intact for the remaining 3 subjects, with the introduction of additional ambiguous baseline relations. For 2 of these 6 subjects, pre- and postambiguity performances could be interpreted clearly in terms of Horne and Lowe's (1996) analysis of intraverbal naming on the basis of their post-experimental naming reports. Performances by the remaining 4 subjects were more difficult to interpret in terms of naming and therefore left open the possibility that these performances could have been driven by the baseline relations rather than by naming strategies.

In Study 2, common names were provided for potentially equivalent stimuli, and all 6 subjects demonstrated that these names were integrated with the equivalence classes before conflicting relations were introduced. After conflicting baseline relations were introduced within each equivalence class, the previously established symmetry relations were disrupted for all 6 subjects, and former transitivity-equivalence relations were reversed for 3 subjects but remained intact for the other 3 subjects. The identification of stimuli according to their common names remained intact for all 6 subjects in the conflicting baseline phase. This reflected a dissociation between previously integrated equivalence classes and common names, which seemed to challenge an interpretation of naming as fundamental to equivalence. However, the possibility that the subjects could have used alternative naming strategies privately could not be discounted.

In Study 3, the subjects were required to speak aloud common names for potentially equivalent stimuli concurrently with conditional discrimination training. Correspondences between overt naming and patterns of emergent relations were of particular interest as a means of evaluating the role of the common names in the formation and maintenance of equivalence classes. Subjects 2, 4, and 5 maintained symmetry and transitivity-equivalence relations and corresponding common naming patterns during the pre- and postambiguity phases, an outcome that seems predictable based on Horne and Lowe's (1996) account of the role of common naming in the formation of equivalence classes. For Subject 6, both equivalence relations and naming patterns were disrupted with the introduction of conflicting relations. Subjects 1 and 3 demonstrated patterns of noncorrespondence between naming and emergent relations, which were evident both before and after ambiguous relations were introduced. These performances perhaps provide the strongest challenge to a view of naming as fundamental to stimulus equivalence: As discussed previously in Study 3, they undermine a view that the use of names is a sufficient and necessary condition for the demonstration of equivalence relations.

In their discussion of the necessity of naming in the demonstration of equivalence relations, Horne and Lowe (1996) allow for the theoretical possibility of a ''different, as yet unspecified, nonverbal route'' (p. 329) for success in equivalence tests. However, they appear to be arguing for this mainly with reference to nonverbal organisms and conclude that the necessity of naming for verbal subjects to pass tests of equivalence ''remains without any serious challenge'' (p. 334). In Study 3, however, the dissociation between naming and equivalence demonstrated by Subjects 1 and 3 suggests that an alternative nonverbal route may be more common in verbal human subjects than Horne and Lowe proposed initially, particularly when there is conflict between the relations specified by the common name and those implied by the baseline relations.

We should be careful, however, in assuming that there is no place for contextual control in Horne and Lowe's (1996) account. In their response to commentaries that suggested this (e.g., Barnes, 1996), they asserted that once the speaker–listener relation is established as a higher order operant, this relation itself can pull in ''a whole variety of events, many of which may be distant in space and time'' (Horne & Lowe, 1996, p. 334). We understand this to mean that events evoked through the naming relation can function as contextual cues, which direct the actual response. In complex matching-to-sample networks, this could mean that depending on the unspecified contextualizing events, the choice of comparison might not necessarily correspond with its assigned name. At first glance it might appear that this allowance for contextual control renders Horne and Lowe's position on naming untestable. It should be possible, however, to design laboratory-based studies that specify or control the contextualizing events and evaluate the effects of these in relation to naming.

To illustrate this with the current study, we could attempt to reconcile inconsistencies observed between preserved naming and reversed emergent conditional discriminations in Studies 2 and 3 by considering whether the new ambiguous relations fostered ''reject'' (R) type rather than ''select'' (S) type responding, which nonetheless reflected integrated equivalence classes (e.g., Carrigan & Sidman, 1992; Johnson & Sidman, 1993). In such a case, it seems reasonable to suggest that a higher order naming relation could evoke events that prompted R type as well as S type responding in the network of relations, so inconsistency between naming and conditional discriminations need not be problematic. This remains possible as a post hoc interpretation of the current study because no verification procedure was introduced to evaluate S type or R type responding. However, had it been considered a priori as a possible contextualizing event, the inclusion of tests for reflexivity would have provided a clarification of S type or R type responding with each subject. In evaluating this under the assumption that naming was the higher order relation, R type responding would cancel the dissociation between reversed emergent relations and preserved naming, whereas S type responding would confirm the dissociation. This, of course, is but one example of the types of manipulations that could help to identify the boundaries within which naming takes a primary role in equivalence, taking into account other forms of control such as baseline relations.

Discussion thus far has assumed that an equivalence class is a discrete unit containing a series of integrated relations. In previous studies, various alternative accounts have been offered to explain the different patterns of effects such as those observed in the current study (e.g., Pilgrim et al., 1995; Pilgrim & Galizio, 1995; Roche et al., 1997; Saunders et al., 1999). Collectively, these studies found a range of conditional discrimination patterns in evidence with baseline reversals or incongruent baseline relations, including maintenance of original symmetry and transitivity relations in a reversed baseline or reversed symmetry with maintained transitivity relations or complete reversal of symmetry and transitivity relations in keeping with the reversed baseline. This range of response patterns was also evident after the ambiguous relations were introduced in this series of studies. However, although response patterns varied considerably between subjects, each subject generally made the same choices consistently within any particular Phase 2 test stage. Such consistency of within-subject responses on individual tests seems to distinguish adults' from children's response patterns with incongruous baselines (e.g., see Pilgrim et al., 1995; Pilgrim & Galizio, 1990, 1995), an outcome that, as noted in these previous studies, could be attributed to a lesser tendency by children to perceive demand characteristics of consistency from among other alternatives. From this perspective, the consistency observed with the adult subjects in this study could be akin to "arbitrary assignment" of conditional discriminations (Carrigan & Sidman, 1992), based on the subjects' previous experimental history of consistently matching one comparison to each sample. No feedback was given during tests, for either baseline or probe trials, so the subjects may have decided arbitrarily, for example, that the new Phase 2 relations should override the original Phase 1 baseline relations or vice versa. Such consistency in emergent matching-to-sample performances was observed previously by Stikeleather and Sidman (1990) when the basis for choice in baseline relations was not clear or unambiguous.

In general, such findings have called into question the view of equivalence as an integrated process, and some researchers have suggested that rather than constituting integrated units, equivalence classes comprise a range of flexible relations (e.g., Pilgrim & Galizio, 1995; Roche et al., 1997; Saunders et al., 1999). As Saunders et al. observed, such within-class flexibility would have more practical utility for the organism than a fixed class containing a series of integrated relations, and this seems to allow for the effects of verbal relations. This perspective provides a very loose analytic framework for the role of naming in equivalence, which perhaps could best be conceptualized in terms of relational frame theory (Hayes, 1994; Hayes & Hayes, 1992).

Essentially, relational frame theory proposes that relational responding is derived as a behavioral principle from a history of responding with contextually controlled stimulus relations. Proponents of relational frame theory (e.g., Roche et al., 1997; Wilson & Hayes, 1996) maintain that derived relational responding as a form of operant behavior would produce dual elements of flexibility and stability within the range of relations demonstrated under different conditions. These patterns were characteristic in the current series of studies with conflicting control, and therefore a post hoc interpretation of these effects in terms of relational frame theory does not seem problematic.

As far as the manipulations permitted, some of the data from these studies challenge a view of naming as fundamental to the demonstration of equivalence relations. Nevertheless, in retrospect various methodological limitations can be identified, which, if addressed, could provide further clarification of this issue.

In Study 3, the requirement to name sample stimuli aloud placed a strong observable element of control over stimulus naming. However, because the X and Y stimuli were not presented as samples, it cannot be established conclusively that covert intraverbal naming of these stimuli was not somehow interacting with overt common naming strategies for some subjects (e.g. Subject 6, Study 3). Although such an account seems to be inelegant, it nevertheless cannot be disregarded on the basis of the current data. This could have been addressed by an additional condition which required alpha or beta naming for sample *and* comparison stimuli, thus imposing an observable naming restriction on the X and Y stimuli. Any ensuing effects from ambiguous baseline relations might more easily have been understood within the context of naming, given this stronger source of naming control. Therefore, this additional element seems worth considering for future studies.

It may be noted that various relations were not tested in Phase 2 of the current studies. For example, symmetry tests for C1-A1 and C2-A2 were not given because they seemed superfluous to the a priori purpose of the investigation, which was to examine whether common naming preserved the integrity of established equivalence classes within a series of ambiguous baseline relations. The current manipulations in Studies 2 and 3 proved sufficient to determine that common naming, symmetry, and transitivity-equivalence relations could dissociate from each other. Likewise, because the X and Y stimuli were not included in the original classes and the ambiguous training did not define their membership of any particular class, tests investigating class membership of the X and Y stimuli also seemed superfluous. However, with hindsight we recognize that including tests for all possible relations with stimuli that are all named overtly could provide a more detailed analysis of the interactions among naming and equivalence relations and ambiguous contextual control. This is especially pertinent because it seems increasingly evident that if equivalence classes constitute a series of flexible rather than integrated relations, an equivalence relation could not be identified sufficiently through a global transitivity-equivalence test.

The focus of these studies has been on exploring the relations among equivalence relations, naming, and contextual control. Evidently, the relations among these three elements are complex, and it seems unproductive to continue to try to establish which is the fundamental process. Indeed, the proponents of both naming theory and relational frame theory have highlighted progress in the understanding of language development as their goal (Hayes, 1996; Horne & Lowe, 1996). Therefore, we may be served better by giving closer attention to how these processes interact. This could provide a greater opportunity for furthering our understanding of language development on a minute scale and also of how this process may in turn extend the complexity of symbolic relations between stimuli to effect an increasingly sophisticated behavioral repertoire.

REFERENCES

Barnes, D. (1996). Naming as a technical term: Sacrificing behavior analysis at the altar of popularity? *Journal of the Experimental Analysis of Behavior, 65,* 264–267.

Carrigan, P. F., & Sidman, M. (1992). Conditional discrimination and equivalence relations: A theoretical analysis of control by negative stimuli. *Journal of the Experimental Analysis of Behavior, 58,* 183–204.

D'Amato, M. R., Salmon, D. P., Loukas, E., & Tomie, A. (1985). Processing of identity and equivalence relations in monkeys (*Cebus apella*) and pigeons (*Columba livia*). *Animal Learning & Behavior, 44,* 365–373.

Devaney, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior, 46,* 243–257.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: The role of naming. *Journal of the Experimental Analysis of Behavior, 58,* 123–133.

Hayes, S. C. (1994). Relational frame theory: A functional approach to verbal events. In S. C. Hayes & L. J. Hayes (Eds.), *Behavior analysis of language and cognition* (pp. 9–29). Reno, NV: Context Press.

Hayes, S. C. (1996). Developing a theory of derived stimulus relations. *Journal of the Experimental Analysis of Behavior, 65,* 309–311.

Hayes, S. C., & Hayes, L. J. (1992). Verbal relations, cognition and the evolution of behavior. *American Psychologist, 47,* 1383–1395.

Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65,* 185–241.

Johnson, C., & Sidman, M. (1993). Conditional discrimination and equivalence relations: Control by negative stimuli. *Journal of the Experimental Analysis of Behavior, 59,* 333–347.

Lazar, R. (1977). Extending sequence class membership with matching to sample. *Journal of the Experimental Analysis of Behavior, 27,* 381–392.

Lipkens, R., Kop, P. F. M., & Matthijs, W. (1988). A test of symmetry and transitivity in the conditional discrimination performances of pigeons. *Journal of the Experimental Analysis of Behavior, 49,* 395–409.

Lowe, C. F., & Beasty, A. (1987). Language and the emergence of equivalence relations: A developmental study. *Bulletin of the British Psychological Society, 40,* A42.

Pilgrim, C., Chambers, L., & Galizio, M. (1995). Reversal of baseline relations and stimulus equivalence: II. Children. *Journal of the Experimental Analysis of Behavior, 63,* 239–254.

Pilgrim, C., & Galizio, M. (1990). Relations between baseline contingencies and equivalence probe performances. *Journal of the Experimental Analysis of Behavior, 54,* 213–224.

Pilgrim, C., & Galizio, M. (1995). Reversal of baseline relations and stimulus equivalence: I. Adults. *Journal of the Experimental Analysis of Behavior, 63,* 225–238.

Roche, B., Barnes, D., & Smeets, P. M. (1997). Incongruous stimulus pairing and conditional discrimination training: Effects on relational responding. *Journal of the Experimental Analysis of Behavior, 68,* 143–160.

Saunders, R. R., Drake, K. M., & Spradlin, J. E. (1999). Equivalence class establishment, expansion, and modification in preschool children. *Journal of the Experimental Analysis of Behavior, 71,* 195–214.

Saunders, R. R., Saunders, K. J., Kirby, K. C., & Spradlin, J. E. (1988). The merger and development of equivalence classes by unreinforced conditional selection of comparison stimuli. *Journal of the Experimental Analysis of Behavior, 50,* 145–162.

Sidman, M. (1990). Equivalence relations: Where do they come from? In D. E. Blackman & H. Lejeune (Eds.), *Behavior analysis in theory and practice: Contributions and controversies* (pp. 93–114). Hillsdale, NJ: Erlbaum.

Sidman, M. (1994). *Equivalence relations and behavior: A research story.* Boston: Authors Cooperative.

Sidman, M., & Cresson, O. (1973). Reading and crossmodal transfer of stimulus equivalences in severe retardation. *American Journal of Mental Deficiency, 77,* 515–523.

Sidman, M., Kirk, B., & Willson-Morris, M. (1985). Sixmember stimulus classes generated by conditional-discrimination procedures. *Journal of the Experimental Analysis of Behavior, 43,* 21–42.

Sidman, M., Rauzin, R., Lazar, R., Cunningham, S., Tailby, W., & Carrigan, P. (1982). A search for symmetry in the conditional discriminations of rhesus monkeys, baboons and children. *Journal of the Experimental Analysis of Behavior, 37,* 23–44.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior, 37,* 5–22.

Spradlin, J. E., & Saunders, R. R. (1986). The development of stimulus classes using match-to-sample procedures: Sample classification versus comparison classification. *Analysis and Intervention in Developmental Disabilities, 6,* 41–58.

Stikeleather, G., & Sidman, M. (1990). An instance of spurious equivalence relations. *The Analysis of Verbal Behavior, 8,* 1–11.

Stoddard, L. T., & McIlvane, W. J. (1986). Stimulus control research and developmentally disabled individuals. *Analysis and Intervention in Developmental Disabilities, 6,* 155–178.

Wilson, K., & Hayes, S. C. (1996). Resurgence of derived stimulus relations. *Journal of the Experimental Analysis of Behavior, 68,* 161–175.

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